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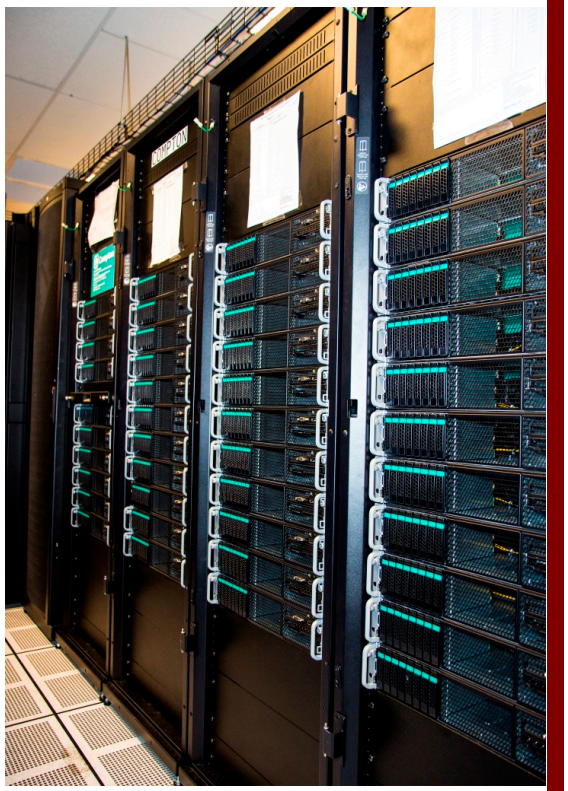
Exceptional service in the national interest

CCR
Center for Computing Research

ISO/C++17 and Beyond: Parallelism and Concurrency (breakout session)

DOE COE Performance Portability

August 22-24, 2017
Denver, CO



SAND2017-8950 PE

Advanced Simulation & Computing

U.S. Department of Energy

National Nuclear Security Administration

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Agenda

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- **DOE Lab participation in ISO/C++ Standard Committee**
  - **Why we are involved – HPC performance portability!**
  - **Your lab's point-of-contact**
  - **How the "sausage is made"**
- **Overview of HPC relevant C++11 & 17 features**
- **Overview of potential (in-the-works) C++20 features**
  - **What in-the-works features are most important to you?**
  - **What high-priority features not in-the-works?**

ISO/C++ Committee : Your Lab's Point-of-Contact

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- **Each lab is an independent corporate member of committee**
  - **One primary representative exercises formal voting rights**
    - **Annual dues, listed in ISO directory, participate regularly**
  - **Alternate representative voting rights in the absence of primary**
    - **Also listed in ISO directory**
  - **Anyone from member org can participate in meetings**
- **Your lab's primary representative (some alternates?)**
  - **SNL – Carter Edwards**
  - **LANL – Stuart Herring**
  - **LLNL – Jim Reus**
  - **ANL – Hal Finkel**
  - **LBNL – Bryce Lelbach**
  - **ORNL – Graham Lopez**
- **FYI: SNL hosting next ISO/C++ Committee Working Meeting**
  - **Nov 6-11 @ Albuquerque**

ISO/C++ Committee : How Sausage is *Slowly* Made

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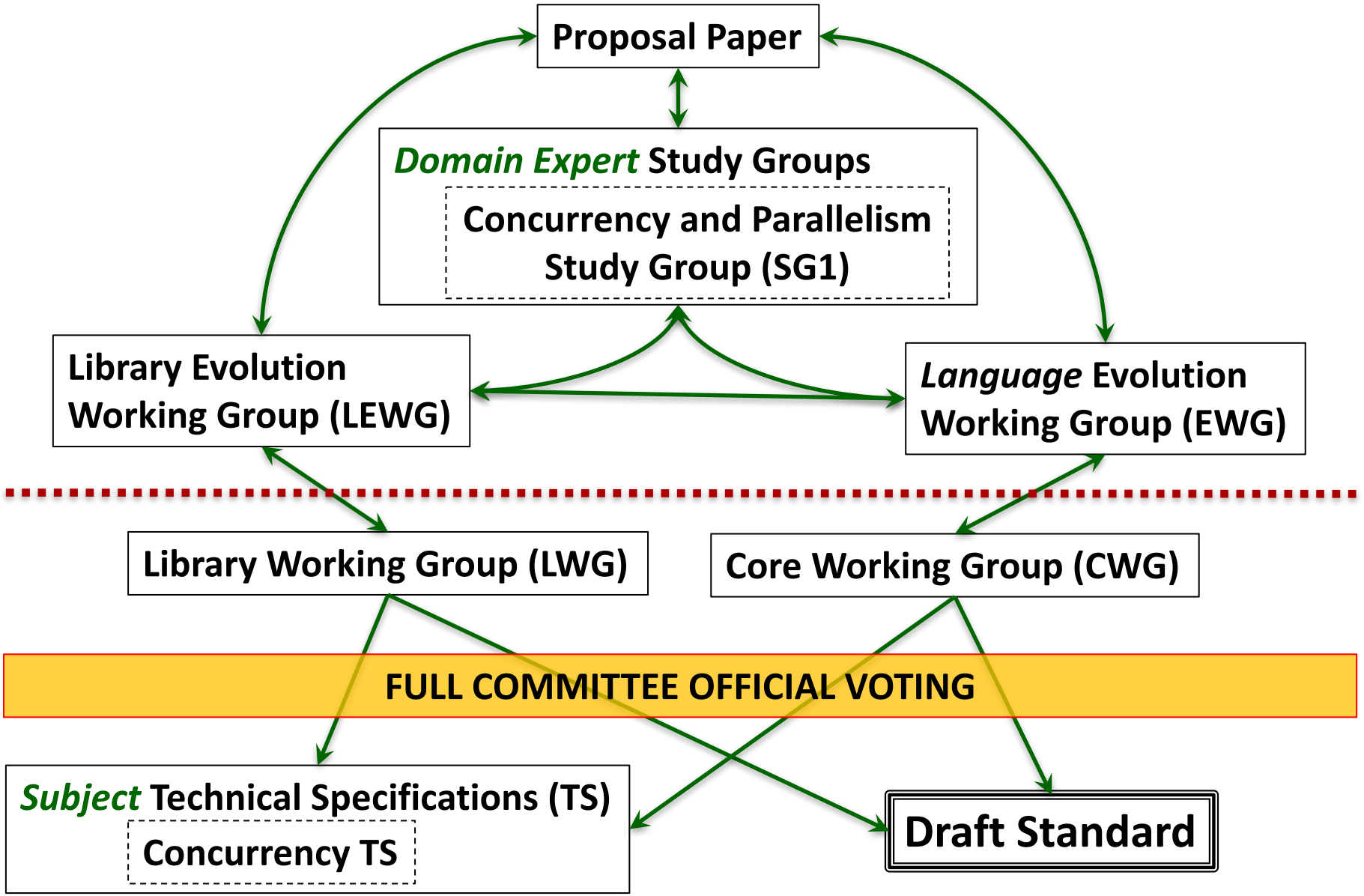

ISO/C++ Committee : Roles & Responsibilities

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- **Proposal Papers**
  - *Anyone* may submit a tracked proposals for
  - Additions or modifications to draft standard or technical specifications
- **Domain Expert Study Groups**
  - Apply domain specific (beyond language/library) expertise; e.g.,
  - Concurrency & Parallelism (SG1), File System (SG3), Networking (SG4), ...
- **Library (LEWG) and Language (EWG) Evolution**
  - Prioritization among always-too-many proposal papers...
  - Broad enough impact to be worth supporting?
  - Well-specified scope, semantics, interactions, and domain-expert review?
- **Library (LWG) and Language (CWG)**
  - Well-specified *standardese* (wording for standard)?
  - "Quality Assurance" – my personal view
  - *Typically* the only groups to bring "straw poll" motions to the full committee
    - Bad form and drama ensues attempting to bypass quality assurance

HPC-Relevant C++11 & 17 Features

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- **Parallel algorithms (C++17)**
  - Allow functors to be executed in parallel on unspecified resources
  - ... important incremental progress, C++20 improvements in the works
- **Atomic Operations and Memory Model (C++11, improved C++17)**
  - Efficient inter-thread communication / synchronization
  - Scalable concurrently modified data structures
- **Threads, Mutexes, and Conditions Variables**
  - C++11 pulled pthreads into the standard w/ name changes & reduced scope
- **Futures, Promises, and Async ☹**
  - ... infamous, whispered about C++11 “Kona compromise”
  - ... avoid using these for now; at least be very cautious

Productivity-Relevant C++11 & 17 Features

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- **Lambda Expressions – inline functors**
  - **C++11: Introduced, dramatic improvement to productivity**
  - **C++17: Language flaw fixed for [*this]**
  - **NVIDIA CUDA 8: Offload lambda expressions to GPU**
  - **Essential for ease-of-use in Kokkos, RAJA, ...**

- **Template meta-programming improvements**
  - **C++11: Variadic template arguments**
  - **C++11: <type_traits>**
  - **C++17: constexpr conditional statements ☺ ☺ ☺ ☺**

HPC-Relevant Potential C++20 Features

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- **Atomic Operations Enhancements**
  - Floating point fetch_add and atomic operations on non-atomic types
  - ➢ Building blocks enabling scalable parallel scatter-add algorithms
- **Latches and Barriers**
  - Atomic-like thread synchronization mechanisms
- **Executors and Execution Context**
  - Executor – specify how concurrent/parallel work is dispatched
  - Context – specify where concurrent/parallel work is dispatched
  - Fix futures and async
- **Wavefront extensions to parallel algorithms**
  - ”Staggered” or “pipelined” parallel execution of loops

HPC-Relevant Potential C++20 Features

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- **Coroutines (TS)**
  - Functions designed to be called iteratively/concurrently
  - Well-defined suspension/resumption
- **SIMD Types – Portable Vector Intrinsics**
  - Guarantee arithmetic operations map to intrinsics for vector hardware
  - Address vector width, intra-lane operations, conditional control flow, ...
- **Multidimensional Arrays (finally!) *with* Polymorphic Layout**
  - Motivated by Kokkos multidimensional arrays
  - Array type includes row major, column major, ... layout specification

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- **Modules (TS) – improve compilation performance**
- **Concepts "light" – improve template meta-programming**
  - Many, many years in the making, with some reputations on the line...
  - ... question has been raised if, given C++17 features, this is still useful 😯

Open Dialogue / Deep Dive as Requested

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- C++11 spec, C++17 draft, proposal papers
  - cppreference.com for C++11, C++14, C++17, and TS toward C++20
  - also have some in-hand
- Priorities for potential features mentioned?
  - May need to be championed by you/your DOE Lab reps
- Important needed features not mentioned?
  - May have failed to mention
  - May need to be added and championed by you/your DOE Lab reps
- Deeper look at existing / proposed features?
  - Sufficient number present want to deep-dive? do it now
  - Otherwise an off-line small group activity